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(54) APPARATUS FOR PRODUCING SPHERICAL PARTICLES

(71) We, POTTERS INDUSTRIES INC., a Corporation organized under the laws of the State of New York, United States of America, of 377 Route 17, Hasbrouck Heights, New Jersey, 07604, UNITED STATES OF AMERICA, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The present invention relates to apparatus for use in the production of spherical particles such as glass spheres.

It is well known to produce glass beads or spheres by introducing crushed glass particles into a vertically disposed draft tube. The tube has a source of heat near its lower end, normally a well distributed gas flame produced by a series of burners. As the combustion gases rise, they proceed into an expansion chamber and carry with them the glass particles which become soft, so that by surface tension the particles are shaped into spherical form. Such bead producing systems are discussed in more detail, for example, in U.S. Patent 2,619,776, granted December 2, 1952, to Rudolph H. Potters and in U.S. Patent 2,945,326, granted July 19, 1960, to Thomas K. Wood.

Heretofore, bead producing furnaces of the foregoing type have been provided with air for combustion at ambient temperature. One of the more common prior systems involved the introduction of the combustion air through an opening in the draft tube below the heat source. The draft created by the rising combustion gases drew ambient air into the draft tube where it was mixed with a combustible fluid and ignited.

As the burning gases rose, much of their heat was transferred through the walls of the draft tube and the expansion chamber. Excessive heating of these walls will result in their deterioration as well as the adhesion of molten glass particles thereto, and in some cases it was necessary to develop cooling systems involving the direction of ambient air against the outer walls of the expansion chamber to meet this problem. These arrangements were basically inefficient, however, and the heat loss through the walls of the expansion chamber resulted in a substantial wastage of the available heat energy.

An object of this invention, therefore, is to provide a new and improved system for conserving energy in the manufacture of glass spheres or other spherical particles.

According to the present invention apparatus for producing spherical particles comprises a furnace including an upwardly extending expansion chamber for making spherical particles, the chamber having a heat conductive wall; a source of heat disposed adjacent the lower portion of the chamber for maintaining the interior of the chamber at an elevated temperature; means for introducing particles of sphere forming material into the furnace between the source of heat and the chamber, the introduced particles being carried upwardly into the chamber by the heat from the source and being shaped by surface tension into spherical form; enclosure means disposed about the chamber in spaced relationship therewith, the enclosure means having at least one infeed opening therein; means for introducing combustion supporting gas into the infeed opening of the enclosure means, the gas introduced through the infeed opening flowing into the space between the enclosure means and the chamber and being raised to an elevated temperature by the heat from the source; and means for withdrawing the heated gas from the said space and for feeding the withdrawn gas to the source of heat.

In a preferred arrangement the furnace includes a substantially vertical draft tube which is located below and opens into the chamber and has an infeed opening for preheated combustion supporting gas adjacent its lower end. The source of heat is located intermediate the ends of the draft tube while the particles of sphere forming material are introduced into the draft tube at a point which is above the source of heat.

The withdrawing means may consist of at least one upstanding discharge duct which communicates with a shroud, which constitutes the enclosure means, and leads to the source of heat. As ambient air is introduced between the shroud and the outer wall of the chamber, the air is heated and enters the duct. The duct directs the preheated air downwardly to the source of heat in the form of a continuous

stream of combustion-supporting gas.

The combustion-supporting gas is preferably introduced into the shroud at a point which is spaced sufficiently from the point where the preheated gas is withdrawn to allow a significant elevation of temperature. The gas is maintained at an elevated temperature as it reaches the source of heat with the result that the overall energy consumption of the apparatus is substantially reduced. The combustion-supporting gas may be fed to the shroud at ambient temperature but under positive pressure and the arrangement is such that a continuous and uniform flow of preheated gas is supplied to the source of heat.

The combustion-supporting gas may be introduced into the lower portion of the shroud and withdrawn from the upper portion, such that the heating of the gas within the shroud causes it to rise and facilitates the flow of gas into the duct. Alternatively the combustion-supporting gas may be introduced into the shroud adjacent its upper portion and removed adjacent the lower portion which will enable the realisation of an even higher elevation of temperature as the gas passes through the shroud.

The combustion-supporting gas may enter the shroud through a plurality of infeed ducts communicating with the shroud at infeed openings therein which are equidistant from each other about the circumference of a chamber of cylindrical form. The heating of the gas is thereby accomplished in a uniform and efficient manner as it flows from the infeed ducts and is distributed around the wall of the chamber.

The apparatus may include a plurality of upstanding discharge ducts which communicate with the shroud at points equidistant about the circumference of the chamber. The opposite ends of these discharge ducts may communicate with the draft tube below the source of heat at equidistant intervals about the circumference of the tube so as to provide a uniform flow of preheated gas to the heat source.

The present invention, as well as further objects and features thereof, will be understood more clearly and fully from the following description of certain preferred embodiments, when read with reference to the accompanying drawings, in which:-

Figure 1 is a diagrammatic front elevational view of apparatus for producing spherical particles in accordance with one illustrative embodiment of the invention,

Figure 2 is a diagrammatic side elevational view of the apparatus of Figure 1, with certain portions omitted for purposes of clarity,

Figure 3 is a fragmentary sectional view t taken along line 3–3 in Figure 1, and

Figure 4 is a diagrammatic elevational view of apparatus for producing spherical particles in accordance with another illustrative embodiment of the invention.

With reference to Figures 1 and 2, a glass sphere making furnace is shown with preheating apparatus in accordance with one embodiment of the invention. The furnace includes a base member 10 and an upwardly extending draft tube 11 resting on the base member. A series of equally spaced gas burners 13 project into the draft tube 11 adjacent its lower portion and extend about the periphery of the tube to provide a source of heat.

The draft tube 11 is cooled in the usual manner by ambient air injected from a duct 15 and an expanded portion 16 to a plenum chamber 17 which surrounds the tube. The cooling air is exhausted through a stack 18.

Extending above the upper end of the draft tube 11 is a cylindrical expansion chamber 20. The chamber 20 surrounds the upper portion of draft tube 11 in coaxial relationship therewith. A collection chamber 22 is located at the lower end of the expansion chamber 21 around the draft tube 11 and is provided with one or more outfeed conduits 24 leading to suitable collecting bins (not shown).

The draft within the draft tube 11 and the expansion chamber 20 is carefully regulated to control the flow of combustion gases from the burners 13. As more fully described in the above Wood Patent 2,945,326, a draft regulator 26 is located at the lower end of the tube 11 and is suitably supported by the base member 10. A cover 27 serves to substantially close the upper end of the chamber 20. The cover 27 includes an opening which communicates with a duct 28, and this duct extends in a downward direction through a separator 29 to a suction fan 30 which exhausts upwardly through a stack 31 open to the atmosphere.

As is well known, crushed glass particles are continuously fed through a suitable infeed conduit 34 to the draft tube 11 at a point which is above the burners 13. In some cases the incoming particles may be preheated in the manner disclosed, for edample, in Arthur G. Nylander U.S. Patent 3,560,185. As the particles enter the tube 11, they are entrained with the upward flow of hot gases from the burners 13. The particles proceed into the expansion chamber 20 and become heated to a temperature sufficient to cause the softening and shaping thereof by surface tension into spherical form. The particles thereupon solidify in the form of glass spheres.

A substantial percentage of the larger spheres falls through the relatively quiescent lateral zones of the expansion chamber 20 to the collection chamber 22. These spheres pass outwardly through the outfeed conduit 24 where they are collected for grading and packaging. The smaller solidified spheres continue their upward movement with the combustion gases in the chamber 20 and pass through the cover 27 and into the duct 28.

The spheres are separated from the entraining gases in the separator 29 and are discharged through an outfeed conduit 32 into suitable containers (not shown).

The system described thus far is merely illustrative of a known combination of sphere-producing components. It will be readily apparent in any such combination that when the apparatus is in operation the temperature within the expansion chamber 20 becomes quite high, and there is a substantial amount of heat which radiates through the cylindrical wall of the chamber and heretofore has been lost to the atmosphere.

The illustrated embodiments of the invention make use of this otherwise wasted heat by employing it to preheat the ambient air or other combusting-supporting gas for the burners 13. The air being fed to the burners is at an elevated temperature, with the result that the fuel consumption of the burners for a given Btu output is greatly reduced. The apparatus operates as a heat exchanger to convert the heat surrounding the expansion chamber into additional energy input to the burners. The resulting saving in fuel costs is substantial, and for burners using natural gas, for example, it is not uncommon to achieve a cost reduction of 25 percent or more through the use of the present invention.

In accomplishing these ends, the expansion chamber 20 is surrounded at least in part by a cylindrical shroud or other enclosure indicated generally at 35. The shroud 35 defines an annular gap between the shroud's inner wall and the outer wall of the expansion chamber 20. The space between the upper edge of the shroud 35 and the expansion chamber 20 is closed by an annular plate 37, and a second annular plate 38 similarly closes the space between the lower edge of the shroud and the chamber.

Four upstanding discharge ducts 40, 41, 42 and 43 are disposed at equidistant locations about the periphery of the cylindrical shroud 35. The upper ends of these ducts communicate with the interior of the shroud 35 and are located in close proximity with the extreme upper portion of the furnace. The ducts extend in a downward direction, and their lower ends are connected to the base member 10 beneath the burners 13. The ducts communicate directly with the burners through the interior of the base member and the draft tube 11.

The shroud 35 is provided adjacent its lower end with a pair of infeed openings 45 and 46. The openings 45 and 46 are circumferentially displaced 180° apart and are respectively located intermediate the adjacent pairs of the ducts 40,and 41, and 42 and 43. Two laterally extending infeed ducts 47 and 48 communicate with the openings 45 and 46, respectively, and these latter ducts lead to a plenum 50. The plenum 50 is of hollow generally cylindrical configuration and is suitably supported adjacent one side of the furnace in juxtaposition with the lower portion of the expansion chamber 20. The plenum 50 is supplied with ambient air at a slight positive pressure by a fan 52 within the infeed opening of the plenum. The fan 52 operates under the control of a drive motor 53.

In operation, the pressurized ambient air within the plenum 50 is directed through the ducts 47 and 48 and into the annular space between the expansion chamber 20 and the surrounding shroud 35. The thus introduced air is preheated by the hot external wall of the chamber 20, and the air rises within the space between the chamber 20 and the shroud 35 and reaches the upper portion of this space under increased positive pressure.

The preheated air then enters the upstanding ducts 40, 41, 42 and 43. The air proceeds downwardly through these ducts and enters the base member 10 immediately beneath the burners 13. The incoming preheated air serves to support the combustion of the burner fuel with the result that substantially less fuel is required than would otherwise be the case. In addition, the ambient air being introduced through the infeed openings 45 and 46 has a cooling effect which serves to maintain the temperature of the exterior wall of the expansion chamber 20 at a reduced level.

In some embodiments the flow of ambient room-temperature air from the plenum 50 is regulated by a damper valve 55. To provide additional control a further damper valve 56 is disposed within each of the upstanding ducts 40, 41, 42 and 43 a short distance above the point at which the duct enters the base member 10. These damper valves are adjustable to insure an evenly distributed flow of preheated air to the source of heat.

In the embodiment of Figures 1–3 the ambient room-temperature air is introduced adjacent the lower portion of the shroud 35 and is withdrawn in the form of preheated air from adjacent the upper portion of the shroud. With this arrangement, the natural tendency of the air within the shroud to rise as its temperature increases serves to assist the flow of preheated air to the burners 13.

In other advantageous embodiments the ambient air is introduced into the upper portion of the shroud and is withdrawn in the form of preheated air from the shroud's lower portion. These latter arrangements make use of the higher temperature adjacent the lower exterior wall of the expansion chamber 20 to provide an even further increase in the temperature of the air leading to the burners 13.

Referring to Figure 4, for example, there is shown a bead furnace of a type similar to that described heretofor which includes a cylindrical shroud 60 around the expansion chamber 20. Communicating with the space be-

tween the chamber 20 and the shroud 60 are four upstanding ducts 63. These ducts are substantially shorter than the upstanding ducts in the embodiment of Figures 1–3 and are arranged such that their upper ends are connected to the shroud adjacent its lowermost portion. The opposite or lower ends of the ducts lead to the base member 10 to direct preheated air to the burners 13 in the manner described below.

The extreme upper portion of the shroud 60 is provided with two infeed openings 67. The openings 67 are in oppositely disposed relationship with each other and communicate with corresponding infeed ducts 70. These latter ducts extend from the shroud 60 in a generally horizontal direction and then proceed downwardly to the plenum 50.

As the fan 52 forces ambient air into the plenum 50, the air is directed under positive pressure through the infeed ducts 70 to the upper portion of the space between the expansion chamber 20 and the cylindrical shroud 60. The thus introduced air is raised to an elevated temperature by the hot exterior wall of the expansion chamber, and the preheated air reaches its highest temperature adjacent the lower portion of the expansion chamber wall because of the comparatively high temperature of the wall at this point. The air proceeds through the upstanding ducts 63, the base member 10 and the draft tube 11 to the burners 13 to supply elevated temperature air to the source of heat.

In some embodiments of the invention preheated combustion air may also be obtained from around the exhaust duct 28 through the use of a shroud around the duct. Such a shroud may be employed in addition to the shroud around the expansion chamber and may be connected to suitable additional ducts to direct the air to the source of heat.

WHAT WE CLAIM IS:-

1. Apparatus for producing spherical particles comprising a furnace including an upwardly extending expansion chamber for making spherical particles, the chamber having a heat conductive wall; a source of heat disposed adjacent the lower portion of the chamber for maintaining the interior of the chamber at an elevated temperature; means for introducing particles of sphere forming material into the furnace between the source of heat and the chamber, the introduced particles being carried upwardly into the chamber by the heat from the source and being shaped by surface tension into spherical form; enclosure means disposed about the chamber in spaced relationship therewith, the enclosure means having at least one infeed opening therein; means for introducing combustion supporting gas into the infeed opening of the enclosure means, the gas introduced through the infeed opening flowing into the space between the enclosure means and the chamber and being raised to an elevated temperature by the heat from the source; and means for withdrawing the heated gas from the said space and for feeding the withdrawn gas to the source of heat.

2. Apparatus as set forth in claim 1, in which the withdrawing means includes a plurality of upstanding discharge ducts for withdrawing the heated gas from the space between the enclosure means and the chamber and for feeding the withdrawn gas to the source of heat.

3. Apparatus as set forth in claim 2, in which each of the discharge ducts communicates with the enclosure means adjacent the upper end of the chamber.

4. Apparatus as set forth in claim 2, in which each of the discharge ducts communicates with the enclosure means adjacent the lower end of the chamber.

5. Apparatus as set forth in any preceding claim, in which the means for introducing combustion supporting gas comprises a pair of infeed ducts respectively communicating with a pair of infeed openings in the enclosure means.

6. Apparatus as set forth in claim 5, in which the chamber and the enclosure means are of cylindrical configuration and extend upwardly in concentric relationship with each other.

7. Apparatus as set forth in any preceding claim, in which the or each infeed opening is disposed in the lower portion of the enclosure means.

8. Apparatus as set forth in any of claims 1 to 6, in which the or each infeed opening is disposed in the upper portion of the enclosure means.

9. Apparatus as set forth in claim 1, in which the furnace additionally comprises a vertical draft tube which is located beneath and opens into the chamber and has an infeed opening adjacent its lower end, the source of heat being disposed intermediate the ends of the draft tube; the withdrawing means includes a plurality of upstanding discharge ducts each of which communicates at a first end with the enclosure means and at a second end with the draft tube at its infeed opening; and the means for introducing combustion supporting gas includes a plurality of infeed ducts each of which communicates at one end with the enclosure means at an infeed opening therein.

10. Apparatus as set forth in claim 9, which further comprises valve means disposed within each of the discharge ducts for regulating the flow of gas therethrough.

11. Apparatus as set forth in claim 9, or claim 10, in which the chamber and the enclosure means are of cylindrical configuration and extend upwardly in concentric relationship with each other.

12. Apparatus as set forth in claim 11, in

which said first ends of the discharge ducts are circumferentially spaced around the upper portion of the enclosure means adjacent the upper end of the chamber, and in which said one ends of the infeed ducts are circumferentially spaced around the lower portion of the enclosure means adjacent the lower end of the chamber.

13. Apparatus as set forth in claim 11, in which said first ends of the discharge ducts are circumferentially spaced around the lower portion of the enclosure means adjacent the lower end of the chamber, and in which said one ends of the infeed ducts are circumferentially spaced around the upper portion of the enclosure means adjacent the upper end of the chamber.

14. Apparatus for producing spherical particles constructed and arranged substantially as herein described with reference to Figures 1 to 3 or Figure 4 of the accompanying drawings.

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1584175 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG.1

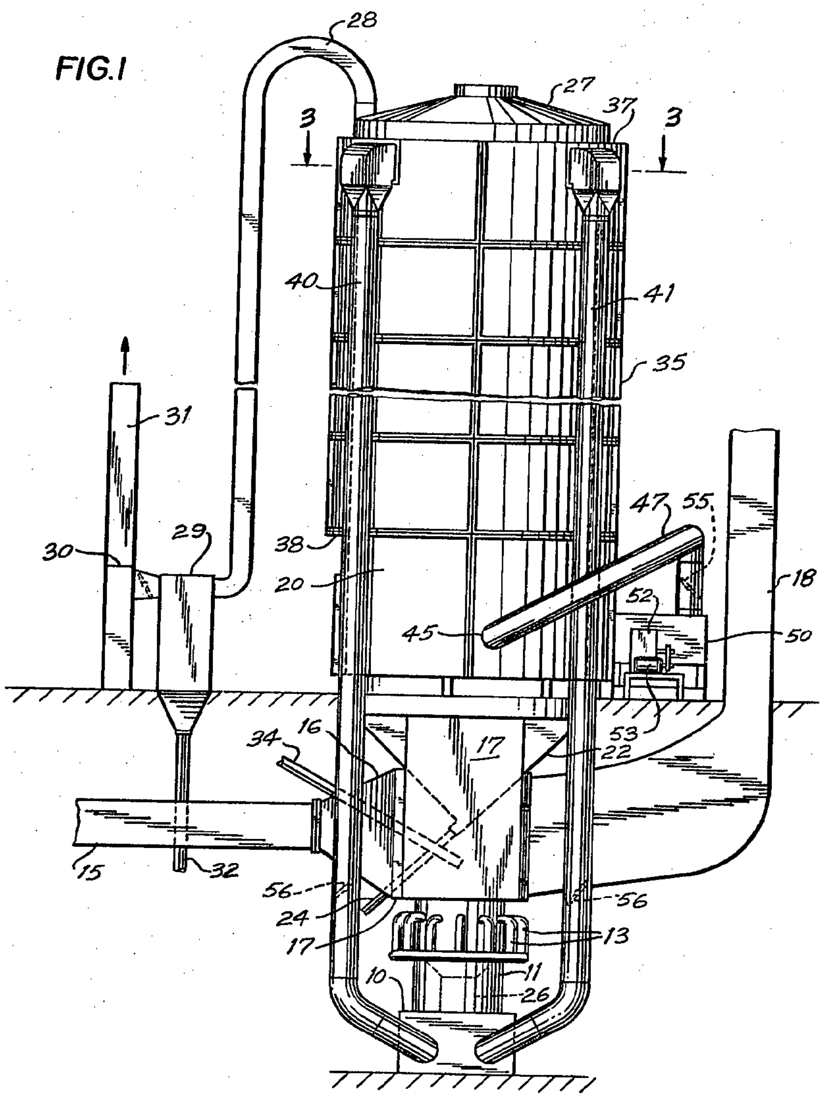
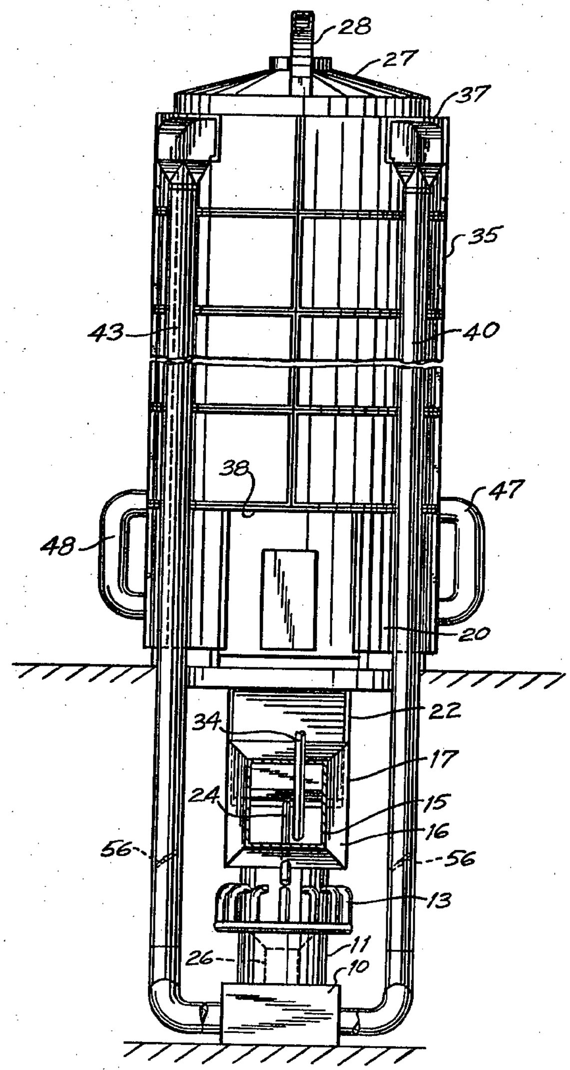


FIG.2



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Sheet 3

FIG.3

FIG.4